

# Automatic Home Appliance Switching Using Speech Recognition Software and Embedded System

Kennedy Okokpujie, Etinosa Noma-Osaghae, Samuel John, Prince C. Jumbo

Department of Electrical and Information Engineering

Covenant University, Ota

Ogun State, Nigeria

kennedy.okokpujie, etinosa.noma-osaghae, samuel.john, (@covenantuniversity.edu.ng)

**Abstract**— In most homes, electrical appliances are controlled and operated manually, this could be difficult and challenging to do when tiredness, handicap, morphological variations (height, aging etc.) and inadequate skill stands in the way as impediment. This study aims to implement a better and more flexible means of controlling home appliances by means of an automated switching mechanism using speech recognition technique. Acoustic signals picked by a microphone controlled by a speech recognition application generate digital signals that are passed to a microcontroller, which in turn dispatches commands that operate the relays to which the appliances in the home are connected. The goal of using speech command to automate the switching of home appliances was achieved and proved to be a more convenient means of switching home appliances.

**Keywords**—*embedded system; speech; switching; android; relays; phonemes.*

## I. INTRODUCTION

For some time humans have aspired to create “Smart machines” which can master the natural speech. This system usually should consist of speech recognition and hardware controlling parts. Speech is an effective way of communicating and ideas could be narrated with relative ease. At the time personal computers were invented, achieving the level of complexity that can relate speech commands to a machine was only a form of science fiction. However with breakthroughs in the field, we are at the stage of truly using speech to interface with devices.

Modern homes today have customized audio theaters, television, electronic lamps, closed circuit television, air conditioners etc. installed in them. The use of speech recognition technology greatly improves the usability and functionality of any modern home [2]. Automating the switching of home appliances using speech recognition technique has lower power consumption and savings in monetary terms as its hallmark. The use of speech to automate the control home appliances can be wired or wireless. The main difference being in the way the home appliances are connected. In the former, home appliances are connected to a central controller but in the latter, they are linked wirelessly. This system provides consumers with increased economic benefit through convenience by giving them remote control

over the switching of every piece of electrical equipment in the house.

Automatic control using speech recognition technology is the process by which a machine or program receives and interprets dictation as well as understands and carries out spoken commands. The process is highly beneficial because it provides a natural and intuitive way of controlling household appliances using speech instead of the hands. Several works have been done on possible remote access approaches for controlling devices thereby providing remote access of home appliances to its owners. This paper concerns itself with the design and implementation of a smart house remote control using software applications interacting with the speech recognition and network actuating system [1].

The analog to digital converter converts the speech signal into digital signal for the computer. The analog to digital converter digitizes the speech signal. This digitized signal is filtered and the noise removed [16]. While filtering, the speech signal is separated into its different bands of frequency and normalized (matching of the speech signal to the speech template stored in the memory of the system for varying speaking speeds). The normalized speech signal is divided into smaller segments and matched with known phonemes. A program finally determines the words being said by the user and displays the output as text and issues a command. This command is sent to the microcontroller, which switches the specified home appliance(s) on or off.

## II. RELATED STUDIES

### A. An overview of speech recognition systems

Speech recognition is a technology that enables a computer to capture the words spoken by a human with a help of a microphone [1] [2]. The process of speech recognition consists of different steps that will be discussed in the following sections one by one. An ideal situation in the process of speech recognition is that, a speech recognition engine recognizes all words uttered by a human but, practically the performance of a speech recognition engine depends on a number of factors. Vocabularies, multiple users and noisy environments are the major factors that affect the performance of speech recognition systems.

### B. Grammar

The sequences of words that can be used are determined by the speech recognition system's grammar domain. A constrain in grammar occurs when the number of word that can correctly follow a selected word are few. This gives the degree of grammar perplexity. Great speech recognition systems have low perplexity as more freedom is given to users to form word commands. Speech recognition systems with high perplexity limit the effective amount of vocabulary that can be formed and used [10].

### C. Isolated words

Speech made with small pauses in between words is easier to recognize than continuous speech. Word boundaries are clearer when the speech is not continuous. Users usually find out that error rates are reduced when speech is made with pauses in between words. This however slows down the speed with which information is fed into the speech recognition system [18].

### D. Single speaker

Speech recognition systems perform optimally when there is only one user of the system. The parametric representation of speech is peculiar to the speaker's intrinsic speech characteristics. A speech recognition system that will perform satisfactorily well when used by multiple users must have training templates from a diverse pool of speakers to ensure that the speech recognition gets a good pattern-matching template for each potential speaker [12].

### E. Vocabulary size

The accuracy of speech recognition systems are seriously affected by the size of vocabulary they have to deal with. The larger the vocabulary size, the more the probability that a speech recognition systems would brand words as ambiguous. Speech recognition systems find it difficult to recognize ambiguous words because their pattern-matching templates look similar to several classifications used by the recognizer. The rate of recognition errors increases with every increase in the speech recognition system's vocabulary size. The time it takes to recognize words is also dependent on the systems vocabulary size. When a speech recognition system has a large vocabulary size, it uses special algorithms to cut down search paths to the most useful. These pruning heuristics, while very useful in speech systems with large vocabulary size, could introduce recognition errors into the system [13].

### F. Environment

The recognition accuracy of speech recognition systems is adversely affected by background noise, loudness and variations in microphone characteristics. The error rate of speech recognition systems reduces drastically with every improvement in environmental conditions (in terms of quietness). The condition of the environment used to train the speech recognition system also plays a major role in determining the system's performance. The system's performance degrades when there is any variation between the environmental conditions used to train the system and the

conditions in which the system is deployed. The use of a noise-limiting microphone significantly improves the performance of the speech recognition system [14].

### G. Natural Language Processing

This can be achieved by playing recorded speech for a speech recognition system. This is called Key Wording. This can also be achieved by speaking in real-time to the speech recognition system. The system uses a set of rules, algorithms and definitions to filters the noise and deduce the user's input. This is called Syntactic and Symantec Analysis. The system uses the rules governing the meaning of words and the syntax for sentence and language formation to deduce the input of user's input [15].

## III. IMPLEMENTATION

The speech recognition technique of switching home appliances was achieved by integrating the following together:

### A. A Speech Capture Device

This consists of the microphone and an analog-to-digital converter to digitally encode the raw speech waveform [18].

### B. A Digital Signal Processing Module

This module performs the function of separating speech from non-speech. It converts the sampled speech signal into its waveform in the frequency domain, windows, scales, filters and compresses the digitized speech signal. This effectively reduces the amount of information the pattern recognition algorithm has to process [17].

### C. Reference Speech Pattern

Speech pattern templates are pre-stored in the database of the speech recognition system.

### D. A Pattern Matching Algorithm

The pattern matching algorithm carries out a matching process to determine the goodness-of-fit between the preprocessed user's speech and the system's stored speech template. The algorithm picks the option with the highest goodness-of-fit ratio. This is usually the best match [13].

### E. Bluetooth

It is a protocol used to transmit information from one node to another without the need of wires. It makes wireless communication between mobile devices and relays possible.

### F. Microcontroller

It wirelessly receives speech commands from the mobile device's speech recognition application and dispatches the speech commands to the appropriate quarters accordingly.

### G. Relays

A network of actuators that switches devices connected to it on or off.

The speech capture device is the mobile device's microphone. The speech recognition android application on the mobile device carries out the digital processing and matching of the speech signal with stored reference speech templates. The Arduino Uno board based on the ATmega328 microchip acts as the microcontroller.

The connection between the microcontroller and android application was wireless. A Bluetooth module (HC-05) was used to connect the microcontroller to an android speech application. The microcontroller (ATmega328p) listens for commands sent to it from the android application. A simple command (coherent speech) allows the application to send parameters to the microcontroller. The microcontroller responds to the signal of the Bluetooth module by sending 5V via a pin into the relay. This acts like a switch for the sockets to which the appliances are connected.

The block diagram of the automatic home appliance switching system using speech recognition technique is shown in Figure 1.

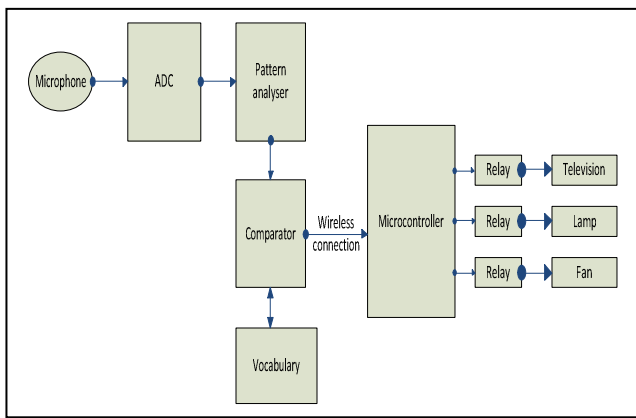


Fig. 1. Block diagram of a system that automatically switches home appliances using speech recognition technique.

#### IV. RESULT

Five persons with different accents and from different age groups were used to test the effectiveness of the speech recognition application and the switching mechanism. Each person said the controlling command for switching the listed appliances thrice (3times). The result of the test carried out on the implemented switching system is displayed in Table I. Table I highlights the speech commands that were programmed to work with the speech recognition system. The commands correspond to the various devices that can be turned on by using speech. To give the command that switches on any particular device, the device's name is called and the word "On" is spoken immediately after. This can be seen from the way the items (speech commands) are written under the 'command' column. The other columns, namely, boy, girl, man, woman and old, tracks the number of times out of three (3), that the corresponding device being controlled responded (by switching on). Figure 2 shows the chart for the result shown in Table 1. The "All on" speech command, switches on

all electrical appliances connected to the microcontroller.

TABLE I. TEST RESULT FOR THE SWITCHING SYSTEM

COMMAND	BOY	GIRL	MAN	WOMAN	OLD
<i>FAN ON</i>	2	1	3	2	1
<i>T.V ON</i>	3	3	3	2	2
<i>LIGHT ON</i>	2	2	2	1	2
<i>ALL ON</i>	3	3	2	3	3

TABLE II. OVERVIEW OF TEST RESULT

Device	Commands		
	On	Off	Total
Television	9	8	12
Lamp	9	8	12
Fan	8	9	12
All	9	8	12

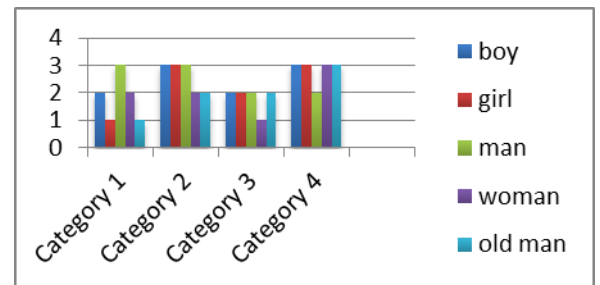


Fig. 2. Chart showing the success rate of the speech recognition system

The study was successfully designed and tested. The results, displayed in Table I and Figure 2 gives the percentage of successful detection of controlling speech commands. Five adults with five different accents were involved in the tests (1 young man, 1 girl, 1 young woman, 1 boy and 1 old man). The purpose of having these people to test the software was to see how well the system performs or responds to differences in accents and pitches when speech commands are issued to it.

The optimum distance of the user should stay from the microphone when issuing speech commands is 18 inches. When speech commands were issued for the first time, it was discovered that it was very vital for users to speak slowly.

In all, the success rate was 84%. This was got from expressing the successful commands as a ratio of the total number of commands issued across all age groups and gender. This ratio was then expressed as a percentage.

## V. CONCLUSION

This study established the fact that an automatic home appliance switching system using speech control was possible and could be made cheaply. The system is highly flexible and scalable since it can use other means of wireless transfer to the microcontroller other than Bluetooth and can be designed to switch as many appliances as desired.

## VI. ACKNOWLEDGEMENT

This paper is sponsored by Covenant University, Ota, Ogun State.

## REFERENCES

- [1] N. Varshney and S. Singh, "Embedded speech recognition system," *International journal of advanced research in electrical, electronics and instrumentation energy*.—2014.—3, pp. 9218-9227, 2014.
- [2] R. A. Aqeel-ur-Rehman and H. Khursheed, "Voice Controlled Home Automation System for the Elderly or Disabled People," *J. Appl. Environ. Biol. Sci.*, vol. 4, pp. 55-64, 2014.
- [3] K. O. Lee, "An all-digital VLSI minimum shift keying modem," *University of British Columbia*, 1992.
- [4] N. KARIMOV, "Hybrid Home Area Network for Automation System," 2016.
- [5] E. Callaway, P. Gorday, L. Hester, J. A. Gutierrez, M. Naeve, B. Heile, et al., "Home networking with IEEE 802.15. 4: a developing standard for low-rate wireless personal area networks," *IEEE Communications magazine*, vol. 40, pp. 70-77, 2002.
- [6] A. Jadhav, S. Anand, N. Dhangare, and K. Wagh, "Universal Mobile Application Development (UMAD) On Home Automation," *Marathwada Mitra Mandal's Institute of Technology, University of Pune, India Network and Complex Systems ISSN*, pp. 2225-0603, 2012.
- [7] H. Schwarz, H. H. genannt Göthe, and U. Heuert, "ANWENDUNG DRAHTLOSER KOMMUNIKATIONSTECHNOLOGIEN ZUM AUFBAU EINES SENSORNETZWERKES FÜR VERTEILTE MESSAUFGABEN," *Zeitschrift für Nachwuchswissenschaftler-German Journal for Young Researchers*, vol. 1, p. 1, 2012.
- [8] J. Gugenheimer, D. Döbelstein, K. Plaumann, F. Geiselhart, P. Hock, C. Winkler, et al., "RTMI'15-Proceedings of the 7th Seminar on Research Trends in Media Informatics," 2015.
- [9] M. Feld, "A speaker classification framework for non-intrusive user modeling: speech-based personalization of in-car services," 2012.
- [10] G. Chung, S. Seneff, C. Wang, and L. Hetherington, "A dynamic vocabulary spoken dialogue interface," in *Proc. ICSLP*, 2004, pp. 1457-1460.
- [11] K. Okokpuije, E. Noma-Osaghae, S. John, and A. Ajulibe, "An Improved Iris Segmentation Technique Using Circular Hough Transform," in *International Conference on Information Theoretic Security*, 2017, pp. 203-211.
- [12] M. Forsberg, "Why is speech recognition difficult," *Chalmers University of Technology*, 2003.
- [13] K. Okokpuije, N.-O. Etinosa, S. John, and E. Joy, "Comparative Analysis of Fingerprint Preprocessing Algorithms for Electronic Voting Processes," in *International Conference on Information Theoretic Security*, 2017, pp. 212-219.
- [14] P. J. Moreno, "Speech recognition in noisy environments," 1996.
- [15] D. Jurafsky and J. H. Martin, *Speech and language processing vol. 3*: Pearson London, 2014.
- [16] K. O. Okokpuije, O. O. Uduchi, and F. O. Edeko, "An Enhanced Biometric ATM with GSM Feedback Mechanism," *Journal of Electrical and Electronics Engineering*, vol. 12, pp. 68-81, 2015.
- [17] K. Okokpuije, F. Olajide, S. John, and C. G. Kennedy, "Implementation of the Enhanced Fingerprint Authentication in the ATM System Using ATmega128," in *Proceedings of the International Conference on Security and Management (SAM)*, 2016, p. 258.
- [18] R. Makhijani and R. Gupta, "Isolated word speech recognition system using dynamic time warping," *International Journal of Engineering Sciences & Emerging Technologies*, vol. 6, pp. 352-367, 2013.
- [19] S. P. Casali, B. H. Williges, and R. D. Dryden, "Effects of recognition accuracy and vocabulary size of a speech recognition system on task performance and user acceptance," *Human Factors*, vol. 32, pp. 183-196, 1990.